

Hints: Is it Better to Give or Wait to be Asked?

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Abstract. Many tutoring systems allow students to ask for hints when they need help solving problems, and this has been shown to be helpful. However, many students have trouble knowing when to ask for help or they prefer to guess rather than ask for and read a hint. Is it better to give a hint when a student makes an error or wait until the student asks for a hint? This paper describes a study that compares giving hints proactively when students make errors to requiring students to ask for a hint when they want one. We found that students learned reliably more with hints-on-demand than proactive hints. This effect was especially evident for students who tend to ask for a high number of hints. There was not a significant difference between the two conditions for students who did not ask for many hints.

Keywords: intelligent tutoring systems, interactive learning environments, computer-based instruction, hints, help seeking, help design

1 Introduction

Many tutoring systems provide hints-on-demand to support students who need help solving problems. There are advantages to allowing the student to have control over when to ask for help. One is the difficulty of a tutoring system deciding when to offer help or what kind of help to offer. For instance, a tutor would respond differently to an error caused by a slip (the student knows the skill but slipped up) or by a misconception or by missing background knowledge [1]. Burton and Brown [2] took a constructivist position and thought that it was best for students to discover as much of the structure of a problem as possible. “Every time the Coach tells the student something, it is robbing him of the opportunity to discover it for himself. Many human tutors interrupt far too often ... and they may be preventing the development in their students of important cognitive skills – the cognitive skills that allow students to detect and use of their own errors.” Studies have shown that providing hints-on-demand can improve learning [3], [4], [5].

Using hints-on-demand depends on student initiative: students are expected to ask for a hint when they want one. Students are expected to know when they need help, how to find and get help [6]. However, students sometimes don’t ask for help when

they should. They may try to guess, especially on multiple-choice questions, which can be quicker than reading and trying to understand a hint. Or students may fear that they will be penalized by the software for asking for help. Alevan and Koedinger [7] found that students frequently failed to ask for a hint after multiple errors, and Alevan et al [8] found that unproductive help-seeking behavior represented 72% of all student actions they observed.

Given that students often exhibit unproductive help-seeking behavior, perhaps tutoring systems should not wait for students to ask for a hint and should give students help before they ask for it. Murray and VanLehn [9] (2006) found that proactive help was more effective for some students and could help save time when a student is floundering and can “provide valuable information at a time when the student is prepared and motivated to learn it, and avoid the negative affective consequences of frustration and failure.”

Which type of help is better? Should we wait for students to ask for help or give help when we think they need it? The purpose of this study was to compare hints-on-demand to proactive hints and to determine which was more helpful to students. Our results showed that students learned significantly more with hints-on-demand than with proactive hints.

2 The Tutoring System: The ASSISTment System

The ASSISTment System [10] aims to assist students in learning the different skills needed for the Massachusetts Comprehensive Assessment System (MCAS) test or (other state tests) while at the same time assessing student knowledge to provide teachers with fine-grained assessment of their students; it assists while it assesses. The system assists students in learning different skills through the use of scaffolding questions, hints, and messages for incorrect answers (also known as buggy messages). Assessment of student performance is provided to teachers through real-time reports based on statistical analysis.

Using the web-based ASSISTment System is free and only requires registration on the website; no software need be installed. The system is primarily used by middle- and high-school teachers throughout Massachusetts who are preparing students for the MCAS tests. Currently, there are over 3000 students and 50 teachers that use the ASSISTment System as part of their regular math classes and/or for homework.

3 Methodology

In this study we focus on “context-sensitive” hints or hints that are pertinent to the task at hand and help the student to learn a skill by doing. Each hint is a message that provides insights and suggestions for solving a specific problem, and is part of a hint sequence of 3-5 hints. Each hint sequence ends with a *bottom-out* hint, which gives the student the answer.

A plumber not only charges \$30 per hour, but he also charges \$10 just to come to your house. Write an expression for how much you have to pay if this plumber works for h hours.

[Comment on this question](#)

Let's try substituting a number for h and computing the answer first.
If the plumber worked for 3 hours at your house how much would you owe him?

Well, the amount owed to the plumber is equal to the amount charged per hour times the number of hours worked plus the amount charged for the house call.

The amount charged per hour is 30 dollars and the number of hours worked is 3.

The amount charged for the house call is 10 dollars.

So, the plumber will charge 90 dollars for the work done plus 10 dollars for the house call, or $90 + 10 = 100$ dollars

[Comment on this hint](#)

Now, if the plumber worked for 3 hours the expression that correctly finds the amount owed to the plumber is the number of hours times the amount charged per hour plus the amount charged for the house call.
or $30 \cdot 3 + 10$

[Comment on this hint](#)

Now, remember we don't actually know how many hours the plumber will work, so we need to use h instead of 3.

We need to add the amount charged for the work to the amount charged for the house call.

The amount charged for the work is $30h$

The amount charged for the house call is 10

The amount owed is $30h + 10$

[Comment on this hint](#)

Type your answer below (mathematical expression):

Submit Answer

Fig. 1. Hints on demand, students ask for each hint by clicking on a hint button. Three hints are shown in yellow boxes.

3.1 Experiment Design

There were two conditions in this study: hints-on-demand and proactive hints. Hints-on-demand presented students with a hint only when they clicked on the hint button (see Fig. 1) and proactive hints presented students with a hint whenever they made an error (see Fig. 2). Students in the study worked on problems in two topics (symbolization and slope/intercept) and participated in both conditions in a repeated measures design. The experiment design controlled for the order of conditions, the

order of topics and the order of problems and students were randomly assigned to one of four groups (see Table 1).

Table 1. Students were randomly assigned to one of four groups.

	Group 1	Group 2	Group 3	Group 4
First Topic	Symbolization	Symbolization	Slope/Intercept	Slope/Intercept
First Condition	Hints on Demand	Proactive Hints	Hints on Demand	Proactive Hints
Second Topic	Slope/Intercept	Slope/Intercept	Symbolization	Symbolization
Second Condition	Proactive Hints	Hints on Demand	Proactive Hints	Hints on Demand

3.2 Participants

This study took place in a typical suburban middle school with 11.5% of students qualifying for free or reduced lunch. There were 72 eighth grade students (aged 12-14 years) who participated in the study during their math enrichment class, 32 females and 40 males.

3.3 Procedure

Students were familiar with the system and used it regularly in a math enrichment class to practice for the MCAS exam. During one class period, students worked on problems in the two topics: symbolization and slope/intercept. Students were presented with four problems in each topic that provided either hints-on-demand or proactive hints. A pretest and post-test of four problems each were given before and after each topic where students received no feedback on their answers. The pretest and post-test problems were the same.

The experiment took place towards the end of the school year and students had been introduced to both topics in their math class. Gain from pretest to post-test was used to measure learning.

A plumber not only charges \$30 per hour, but he also charges \$10 just to come to your house. Write an expression for how much you have to pay if this plumber works for h hours.

[Comment on this question](#)

[Break this problem into steps](#)

Type your answer below (mathematical expression):

[Submit Answer](#)

Let's move on and figure out this problem.

Here is a hint:

Let's try substituting a number for h and computing the answer first. If the plumber worked for 3 hours at your house how much would you owe him?

Well, the amount owed to the plumber is equal to the amount charged per hour times the number of hours worked plus the amount charged for the house call. The amount charged per hour is 30 dollars and the number of hours worked is 3. The amount charged for the house call is 10 dollars.

So, the plumber will charge 90 dollars for the work done plus 10 dollars for the house call, or $90 + 10 = 100$ dollars

Try writing an expression for how much you owe the plumber if he worked for h hours.

[Comment on this question](#)

[Break this problem into steps](#)

Type your answer below (mathematical expression):

[Submit Answer](#)

✗ Sorry, that is incorrect. Let's move on and figure out why!

Here is another hint:

Now, if the plumber worked for 3 hours the expression that correctly finds the amount owed to the plumber is the number of hours times the amount charged per hour plus the amount charged for the house call. or $30 \cdot 3 + 10$

What is the expression if the plumber worked for h hours?

[Comment on this question](#)

[Break this problem into steps](#)

Type your answer below (mathematical expression):

[Submit Answer](#)

Fig. 2. Proactive hints: hints are presented automatically when a student submits an incorrect answer

4 Results

Gain scores from pre- to post-test were used to measure learning. Students learned from problems in both topics. The average gain for the Symbolization problem set was 12% [$t(60) = 3.7, p < 0.001$] and the gain for the Slope/Intercept problem set was 4% [$t(66) = 1.37, p = 0.17$]. Of the 72 students who participated in the study, 61 students completed both conditions and contributed to the repeated measures analysis.

We were interested in determining if there was a difference in the effectiveness of each condition based on students' math ability. Students had completed a practice MCAS test and the median score on the test was 75%. A median split on the practice MCAS scores was used to split students into "high math ability" or "low math ability." However, there was no significant difference found based on an aptitude treatment interaction.

Table 2. Student gains in the two topics.

	N	Mean	Std. Deviation	Std. Error Mean
Gain in Slope	67	.0410	.24463	.02989
Gain in Symbolization	61	.1208	.24996	.03227

The repeated measures analysis showed that students learned significantly more [$F(59, 1) = 4.42, p = 0.04$] from hints-on-demand and having control over when to ask for a hint (mean gain score = 0.137) compared to having the computer control when to give a hint (mean gain score = 0.04). The effect size of 0.35 has a 95% confidence interval of [0.02 - 0.74]. The results of this analysis can be found in Table 3 and Fig. 3.

Table 3. Students gained more with hints-on-demand

	Math ability	Mean	Std. Dev.	N
Gain with Proactive hints	High	.0429	.2386	35
	Low	.0385	.2201	26
	Total	.0410	.2290	61
Gain with on-demand hints	High	.1429	.2521	35
	Low	.1282	.3120	26
	Total	.1366	.2768	61

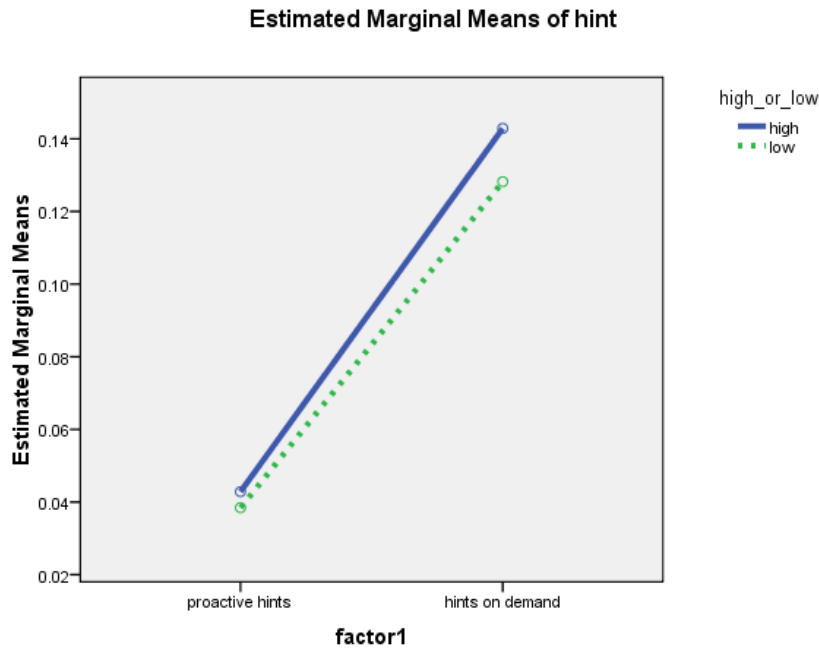
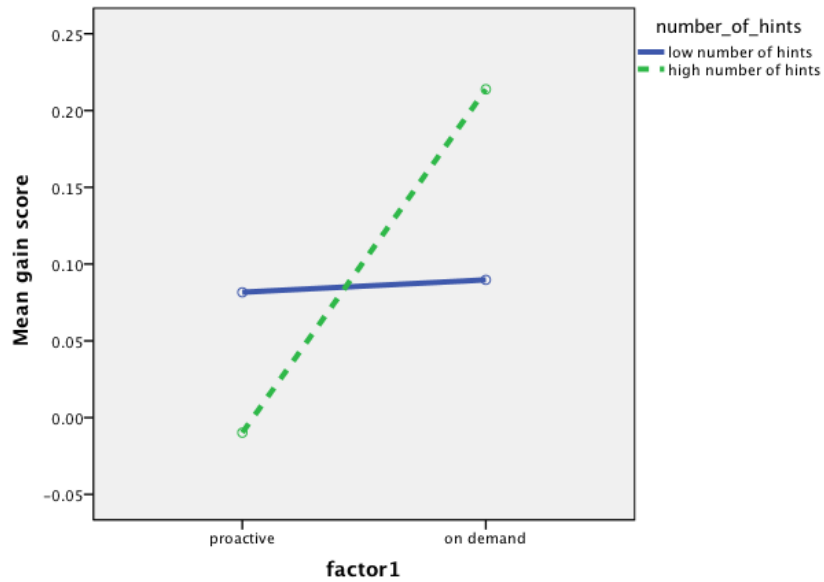


Fig. 3. Students of both low and high math ability learned more from hints on demand.

We looked at the number of hints students requested when they were in the hints-on-demand condition. Not surprisingly, students with low math ability asked for significantly more hints (mean = 11 hints) than students of high math ability (mean = 5.4 hints), [F(71, 1) = 10.85, p = 0.002]. The median number of hints requested in the hints-on-demand condition was seven hints and a median split on the number of hints requested was used to divide students into two groups: “high number of hints” and “low number of hints.”

For students who asked for a high number of hints, hints-on-demand were significantly more helpful than proactive hints [F(29, 1) = 7.358, p = 0.01]. However, for students who ask for a low number of hints, there was not a significant difference between the two conditions [F(28, 1) = 0.077, p = 0.78], (see Fig. 4).

The interaction between condition and the number of hints requested, using the number of times the bottom-out hint was reached as a covariate, was marginally significant [F(56, 1) = 3.199, p = 0.079].



Covariates appearing in the model are evaluated at the following values:
 number_times_reach_bottom_hint = 2.20

Fig. 4. Students who tend to ask for many hints do significantly better with hints-on-demand

We looked at the number of times students reached the bottom-out hint, which gives the answer to the problem. The median number of times a student reached the bottom-out hint was used to divide students into “low bottom-out hinters” and “high bottom-out hinters.” Although students who were low bottom-out hinters learned more in both conditions than students who were high bottom-out hinters, both groups had higher learning gains with on-demand hints [$F(59, 1) = 4.74, p = 0.033$]. (See Table 4.)

Table 4. Both high and low bottom-out hinters had higher learning gains with on-demand hints

	bottom_out_hint_level	Mean	Std. Deviation	N
gainProactive	low bottom-out hinters	.0833	.21348	33
	high bottom-out hinters	-.0089	.24039	28
	Total	.0410	.22904	61
gainDemand	low bottom-out hinters	.1591	.28517	33
	high bottom-out hinters	.1101	.26937	28
	Total	.1366	.27682	61

5 Conclusion

In this paper, we described a randomized controlled experiment to compare hints-on-demand to proactive hints in a tutoring system. We used a repeated measures design so all students saw both conditions. We found that middle school students working on algebra problems did significantly better with hints-on-demand and having control over when to see a hint compared to being shown a hint when they made an error, with an effect size of 0.35.

Interestingly, students who tended to ask for a high number of hints learned significantly more with hints-on-demand, but for students who asked for a low number of hints there was no significant difference between the two conditions. We do not know the reason for this result. It may be that the students who asked for a high number of hints had good help-seeking behavior and benefitted from controlling the timing of help so that they received it at the most useful moment. Proactive help may have been distracting or annoying to these students. The students who asked for a low number of hints may have been unproductive help-seekers who avoided asking for help when they needed it. These students may have benefitted from being shown a hint when they needed one.

If we had to recommend one method of providing help over another, hints-on-demand seems to be the better choice since it had better results overall, better results for high-hinters and little difference for low-hinters. However, this study did have its limitations. Students who participated in this study were more familiar with hints-on-demand as that is the norm in the ASSISTment System and students had been using the system throughout the school year. Although we explained to the students that they would see the two different types of hints, the proactive hints were unfamiliar and perhaps confusing. This study also took place over a very short period of time and students had little time to get used to the proactive hints. For future work we would like to repeat the experiment over a longer period of time with more students.

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